Progress Report: NOAA GAPP

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The Effects of Orography on the Cold-season Hydrometeorology in California

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Period of performance: June 2003 – December 2003

OVERVIEW

The main objective of this project funded by the NOAA-GAPP program is understanding the roles of mesoscale terrain, in particular the Coastal Range and the Sierra Nevada, in shaping the cold season climate and water cycle in California using a regional climate model (RCM) and observations. The knowledge gained from this study will provide valuable insights in the water cycle in California and how they are affected by the variations in the large-scale circulation, one of the primary concerns in extended-range forecasting and climate change impacts assessments.

For the first-year, the PI proposed to perform

(1) Begin cold-season simulations for the winter of 1997-1998 using an RCM,
(2) Identify precipitation events for intensive case studies,
(3) Start analysis of the CALJET/PACJET datasets in collaboration with the NOAA/ETL,
(4) Discuss future experiment plan with the NOAA/ETL, and
(5) Submit the first-year progress report.

For the reported period, most of the research efforts has been put on evaluating the RCM in a number of case studies, and collecting observed datasets for evaluation. Initial planning of incorporating the observed low level winds during the CALJET/PACJET has been discussed with the NOAA/ETL as well.

OUTLINE OF THE PROGRESS DURING THE REPORT PERIOD:
JUNE 2003 - March 2004

1. Evaluation o the RCM in cold-season simulations

As the first step for investigating the effects of mesoscale orography on the cold season climate and water cycle in California, a number of simulations were performed using an 18-km resolution California domain (Fig. 1). This domain covers entire California with a buffer region for implementing the large-scale forcing along the lateral boundaries, as well as for generating mesoscale disturbances associated with the two mountain ranges in the central part of the domain. At this spatial resolution, the model terrain well represents the shape of the Coastal Range and the Sierra Nevada that are expected to affect the cold season low-level moisture budget in the upstream sides of both mountain ranges.

The case studies covered periods ranging from a few days to 4 winter months, December-January-February-March. These short-term case studies included two heavy precipitation events, February 1986 in the northern Sierra Nevada, and February 1998 in southern California. These studies examined how RCM-simulated cold season precipitation were affected by precipitation fallout schemes and different large-scale forcing datasets.
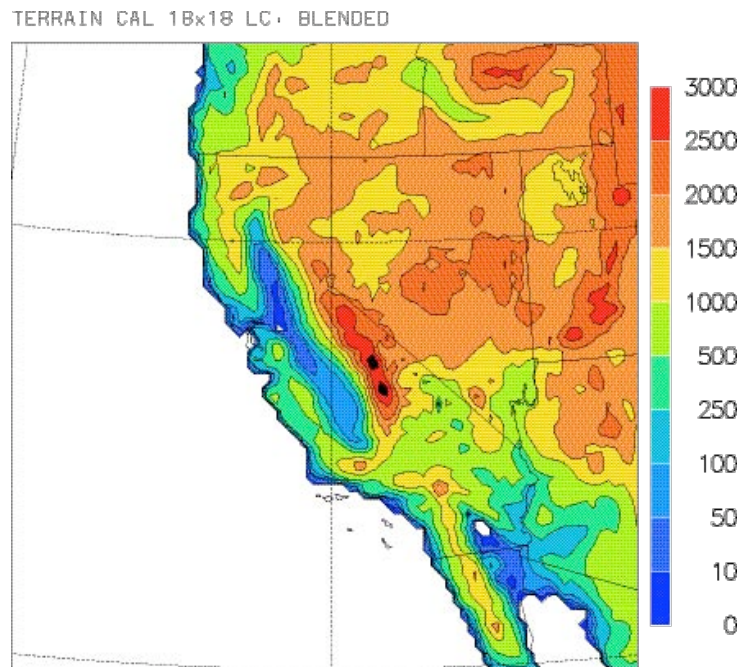

Figure 1. The domain and model terrain elevations of the 18 km –resolution California domain.

The simulated precipitation in the short-term case studies compared well with observed data, but the results showed significant sensitivity to precipitation fallout schemes and the source of the large-scale forcing data. The most notable effects were from the source of the large-scale forcing data. Figure 2 compares the total precipitation from the February 1986 case studies driven by two large-scale analysis fields, the NCEP Reanalysis 2 (R2) and the ECMWF Reanalysis (ER).
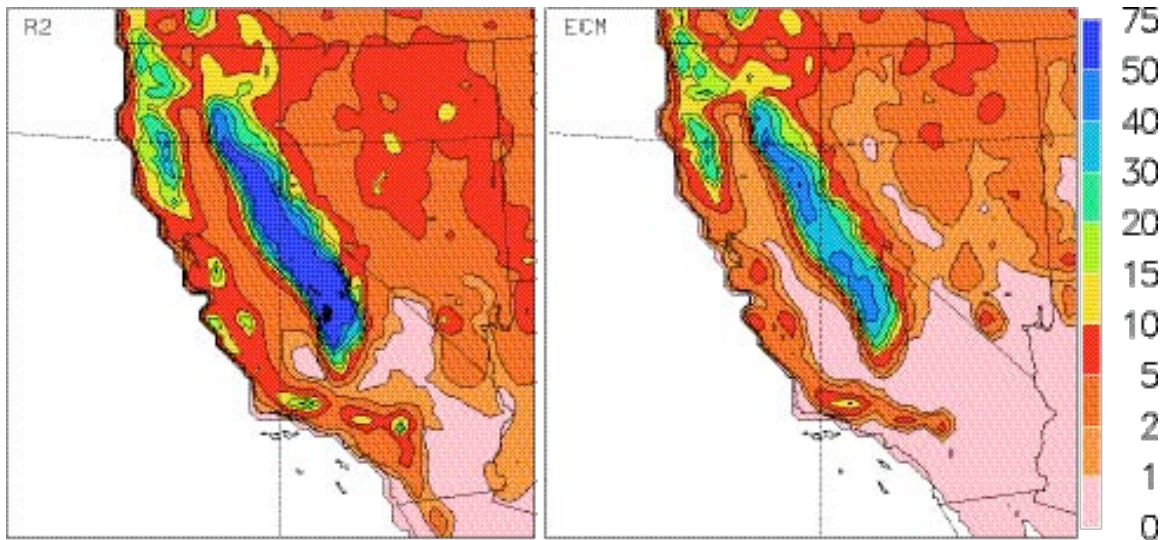
Figure 2. Total precipitation (inches/12days) for the February 1986 extreme precipitation case study.

Both simulations driven by the large-scale forcing data from the R2 and ER generated similar spatial distributions of the simulated precipitation within the domain. The amount simulated precipitation driven by the ER agrees well with observations in the northern Sierra Nevada in which over 50" of rain was observed in the Feather River basin during the 12-day period (Kim and Soong 1996). The run with the R2 forcing resulted in a much wetter simulation than the ER-driven run in general. Precipitation in the Sierra Nevada was especially overestimated. The rainfall peaks in the southern Coastal Range in the R2-driven simulation, however, agrees more closely with observation than the ER-driven one. Similar differences in the simulated precipitation between the R2- and ER-driven runs were observed in the February 1998 case.

Examination of the water vapor fields interpolated onto the model grids from the R2 and ER showed a large differences from each other, suggesting that the differences in the simulated precipitation originated mainly from the differences in the amount of water vapor in the two reanalysis datasets. This sensitivity of the simulated precipitation to the large-scale data, especially the results with the R2 forcing data, is important for this study as only R2 datasets are available for the periods in which the CALJET/PACJET datasets are available.

The seasonal runs also simulated well monthly precipitation for the three winters. The simulated monthly precipitation for the 1997-1998 winter (December 1997–March 1998) is presented in Fig. 3. The contrast in precipitation between wet January/February and dry December/March was well represented in the simulation. Similarly to the February 1986 extreme precipitation event driven by the R2, however, the simulation run overestimated the observed monthly precipitation as well. We plan to repeat these seasonal simulations by driving the RCM with more accurate Eta-model initial fields to examine whether the water vapor fields in the R2 are generally too wet compared to other reanalysis products. Based on the outcome of these additional experiments, final decision on the large-scale forcing datasets for the main experiments will be made.

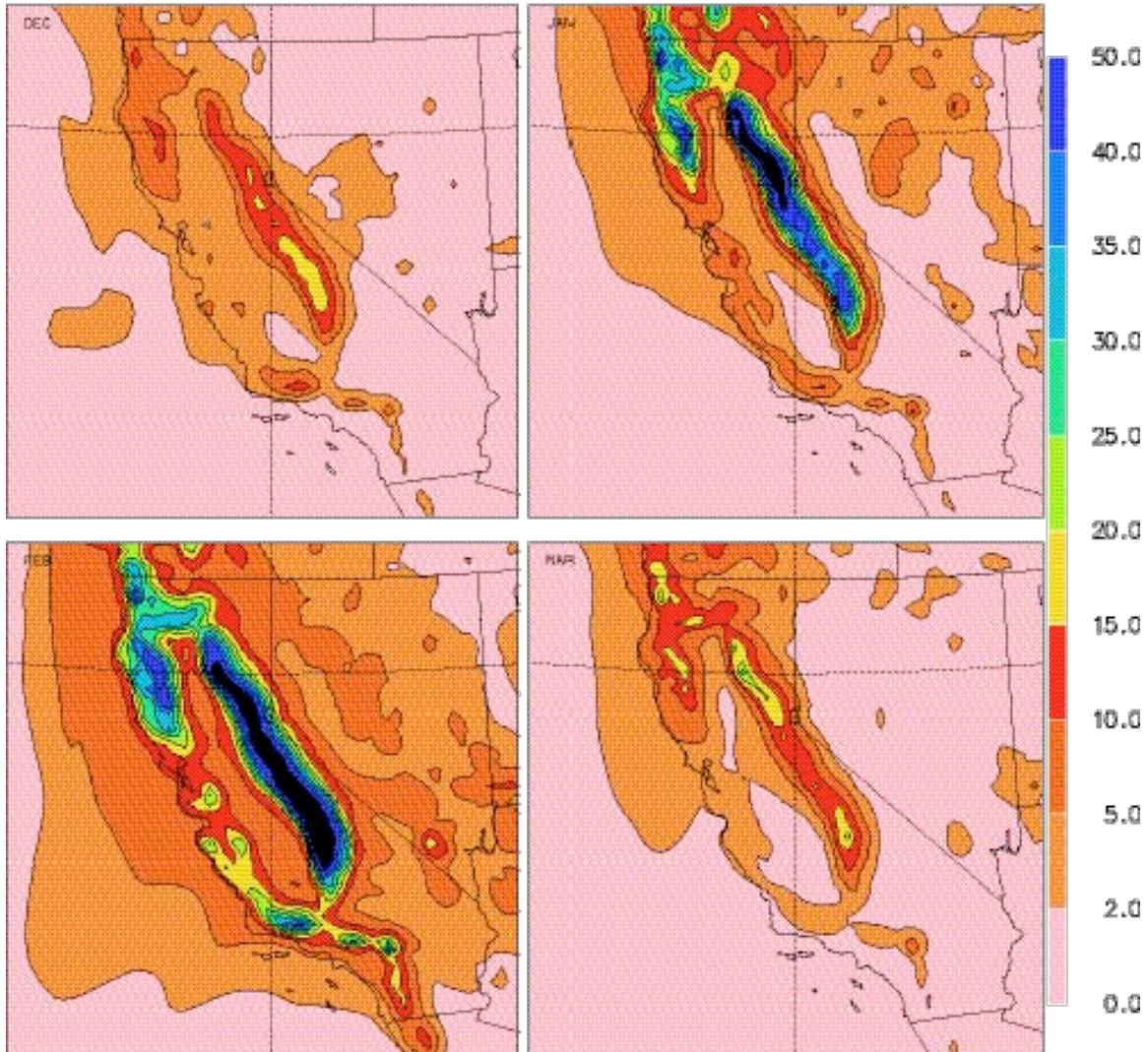MAS MO PRCP [MM/DAY] WNTR 1997-1998

Figure 3. The simulated monthly precipitation during the winter of 1997-1998.

2. Identification and classification of storm events

The next step of this investigation includes analyses of the simulated and observed low-level wind and water vapor fields for detailed examination of the effects of the mesoscale disturbances on the water cycle in California. This part of the study was intended to be closely coordinated with the NOAA/ETL.

For identifying storm events, NCEP-URD daily rainfall dataset for the period 1948-2002 was imported for analysis. Examination of this fine-scale dataset in known precipitation cases showed that the dataset well represents daily precipitation events in California even though local extremes are generally underestimated, often seriously. Hence, this dataset is adequate for identifying past storm events in California. A comparison of the simulated daily precipitation against the NCEP-URD showed that the RCM driven by the R2 can generate daily precipitation sequence similar to the one depicted by the NCEP-URD.

For the classification of warm and cold storm events, the low-level temperatures and the strength of stratification over the Eastern Pacific Ocean during individual storms will be obtained from the R2. Initial planning for this part of the study was discussed with Dr. Marty Ralph at the NOAA/ETL who is the leading collaborator in this effort. In addition, the PI is collaborating with the NWSO-LA/Oxnard for identifying the storm events that caused significant local impacts.

3. Collaborations and additional datasets

One of difficulties in this study is a lack of observed water vapor fields, that are crucial for investigating regional water budget associated with low-level barrier jets, one of the most important terrain-induced mesoscale disturbances that affect regional water cycle. In an attempt for obtaining reliable local water vapor fields, the PI is collaborating with a research group at the NASA/JPL who are working on estimating the precipitable water vapor (PWV) fields from GPS receivers. Through this collaboration, the PI has obtained the PWV fields during an 8-day periods in February 1998. Figure 4 presents an example of the PWV fields obtained by a GPS array in southern California.
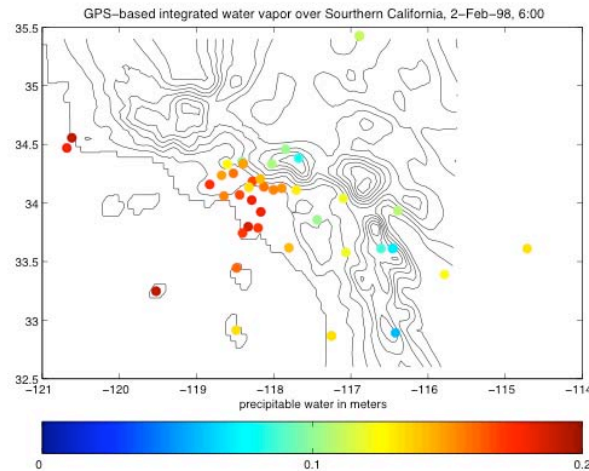

Figure 4. The GPS-based PWV fields over southern California at 06:00 on Feb. 2, 1998.

This collaboration is expected to go smoothly, and the PWV data to be obtained through this collaboration will be combined with the wind data from the NOAA/ETL to construct mesoscale water vapor fluxes.

4. Research Plan for the Second year

The research plan during the second year aims at completing the case studies and RCM evaluations. The low-level winds and water vapor fields from seasonal simulations will be analyzed for constructing their roles in the water cycle in California. Observed data for the low-level winds and PWV will be obtained from the NOAA/ETL and NASA/JPL and analyzed for selected storm events.

(1) Complete seasonal simulations and evaluate the results against observations. Based on the results so far, this part of the study is expected to proceed smoothly.
(2) Perform case studies for selected storm events and analyze the results.
(3) Obtain the low-level wind measurements and the PWV from the NOAA/ETL and the NADA/JPL for selected cases.
(4) Submit a paper from seasonal simulation studies.
(5) Submit the second-year project report.

5. Publications and Presentations Supported by the Project

Kim, J., 2004: The barrier jets and associated moisture transports in California during the winter of 1997-1998. under preparation.